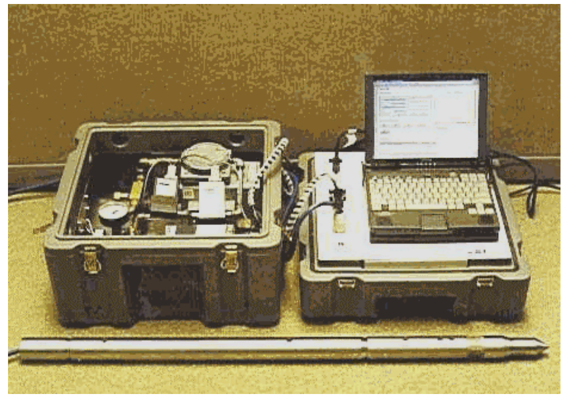
Cone Permeameter™

The Challenge



Cone Permeameter™ equipment including probe, instrumentation and pump box, and analysis computer.

The vadose zone surrounding the underground waste storage tanks at the Department of Energy's Hanford Site contains contaminants that have entered the soil from tank leaks. Characterization of both the radiological and chemical contamination as well as the geohydrological properties is important for modeling to determine the contamination movement in the future as well as to design containment and remediation approaches. A typical geohydrological parameter needed for these calculations is the permeability of the soil. Permeability is the measure of the magnitude of fluid flow in the soil under imposed pressure gradients. A fast, reliable means of measuring permeability greatly aids the characterization process. With this information, a means of predicting contaminate movement, containment systems, and remediation techniques can be developed.

Current Approach

Permeability is typically measured using laboratory analysis of soil samples removed from the formation. The soil samples are tested in the laboratory by injecting a fluid in one side of the sample and measuring how long it takes to pass through the sample. Measurements are made using both air and water as the injection fluid, although saturated measurements are the most common. One drawback of the laboratory testing technique is that great care must be taken when the samples are collected to minimize the disturbance the soil structure of the sample. The soil structure can have a great influence on the permeability measurement.

Two types of field tests are occasionally conducted to gather large-scale permeability estimates. The first is a pumping test, which is conducted over a very large scale, is expensive and therefore only used on large projects. This test may also move existing contaminate and must be used with care. Another field test that is more commonly used is a single well slug test. The test regions of a well are packed off and water injected into the formation. The time to inject a given volume of water or air is used to determine the permeability.

Benefits and Features

- Fast, single-point, in situ measurements
- Real-time results available
- No drilling waste generated

New Technology

The Cone Permeameter™ (CPer) system, developed by Science and Engineering Associates, Inc., is a technology which uses a cone penetrometer (CP) as a delivery system and has the capability of measuring both in-situ air permeability and saturated hydraulic conductivity of soils. The measurement system utilizes a spherical flow geometry methodology. The basic premise of the approach is that as fluid is injected from a discrete point of the penetrometer rod it will result in a spherical flow pattern as the fluid moves outward from the rod. Eventually, for a given injection rate, the radial pressure profile along the axis of the penetrometer rod is identical to that which would occur if the rod did not exist. Measurement of the pressure gradient at a distance from the injection point produces the required information to calculate the permeability of the formation.

This approach to characterization allows multiple readings to be taken at specific depths during a single push. Each permeability measurement takes about ten minutes and the results are immediate with no laboratory analysis or waste disposal.

Demonstration Description

The purpose was to evaluate the CPer's ability to measure air permeability in arid sands, silts and gravels; and to determine the system's ability to replicate permeability profiles with multiple pushes in close proximity. The CPer was demonstrated using the Hanford Cone Penetrometer Platform developed and operated by Applied Research Associates, Inc. The demonstration required numerous test pushes within ten feet of a previously characterized monitoring well at the Immobilization Low-Activity Waste (ILAW) site in the 200 East Area. Permeability measurements were conducted approximately every meter from the ground surface down to the CP push refusal depth.

Demonstration Results

Four separate penetrations were completed, with the maximum depth attained at 62 feet (18.91 meters). Of the 33 permeability measurements attempted, 10 produced no pressure change between the pressure ports, indicating either clogged ports or a permeability outside the measurement range of the sensor. The successful measurements indicated permeabilities ranging from 0.033 to 8.27 darcies (3.28E-14 to 8.16E-12 m^2). Pushes in close proximity to each other indicated permeability profiles agreeing within one order of magnitude (frequently much closer than that). Measurements were conducted in a zone where two core samples had been taken for laboratory analysis of saturated hydraulic conductivity. The equivalent saturated hydraulic conductivity obtained agreed with the laboratory samples to within half an order of magnitude. The CPer demonstration validates the technology for future applications and has the potential to aid in developing contamination mobility models important for supporting cleanup decisions.

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